METHOD FOR HARD HANDOFF IN A CDMA CELLULAR ENVIRONMENT

TECHNICAL FIELD

The invention relates generally to code division multiple access ("CDMA") cellular telephone systems and, more particularly, to a method for performing a hard handoff of a call from a CDMA cellular telephone system to another cellular telephone system such as an advanced mobile phone service ("AMPS") cellular telephone system or another CDMA cellular telephone system utilizing a different operating frequency.

BACKGROUND OF THE INVENTION

A cellular telephone system serves a defined area by dividing the area into cells. Each cell is served by a single base station, or cell site, and each cell site is connected to a message switching center ("MSC") via appropriate hardware links. A mobile unit is connected to the MSC by establishing a radio frequency ("RF") link with a nearby cell site.

Currently, there are several different types of cellular access technologies for implementing a cellular telephone network, including, for example, code division multiple access, or "CDMA", and advanced mobile phone service, or "AMPS". In a CDMA network, a single radio frequency is used simultaneously by many mobile units and each mobile unit is assigned a "code" for deciphering its particular traffic on that frequency. In contrast, in an AMPS network, each mobile unit is assigned a different radio frequency on which to communicate.

Referring to FIGS. **1A–1D**, it will be recognized that, as shown in FIG. **1A** and as previously described, in order for a mobile unit such as a mobile unit **10** to communicate in a cellular telephone network such as a CDMA network **12**, several links must be established. These links include an RF link **14** between the mobile unit **10** and a first cell site, such as a cell site A, and a hardware link **16** between the cell site and a mobile switching center ("MSC") **18**. As shown in FIG. **1B**, as the mobile unit **10** moves away from the cell site A, the RF link **14** weakens and will eventually become too weak to support communications between the cell site A and the mobile unit **10**. As a result, the call in progress eventually disconnects, or is dropped. Clearly, this is not acceptable. Referring to FIGS. **1C** and **1D**, to avoid this result, when the mobile unit **10** crosses a cell boundary **20** into a second cell of the network **12**, in this case the cell served by cell site B, a new communications path between the mobile unit **10** and the MSC **18** is established. Cell site B serves a bordering cell to that of cell site A because the two cells are adjacent to each other. The new communications path includes an RF link **22** and a hardware link **24** between the cell site B and the MSC **18**. Therefore, at the cell boundary **20**, the mobile unit **10** is directed to end communication with the cell site A and begin communication with the cell site B.

The situation in which a mobile unit ends communication with one cell site and begins communication with a second cell site is referred to as a "handoff". The specific example illustrated in FIGS. **1A–1D** is referred to as a "hard handoff" because the link between the mobile unit **10** and the MSC **18** via the cell site A is broken before the link between the mobile unit and the MSC via the cell site B is established. Alternatively, a "soft handoff" occurs when a second link to the mobile unit **10** is established before the first link is broken. For example, a soft handoff occurs in a CDMA network when a call is passed from a first cell site to a second cell site wherein both cell sites operate on a common frequency.

Often, an AMPS cellular network already exists in an area in which a CDMA network is to be installed, in which case the CDMA network will often be overlaid on top of the AMPS network. As a result, one or more cell sites of the CDMA network are "co-located", or placed in a one-to-one overlay, with an equal number of cell sites of the AMPS network. In such a case, there may be situations in which it would be advantageous to effect the handoff of a call from a CDMA cell site to an AMPS cell site. For example, there may be areas that are covered by a cell site of the AMPS network that are not covered by a cell site of the CDMA network, due to different link/power-supply constraints between the two cell sites, slight differences in the location of the various cells, and holes, or nulls, in the CDMA network coverage due to topography and cell site planning. Such coverage holes in the CDMA network can degrade call quality and, at worst, result in dropped calls. In addition, many cellular service providers have existing in-building and/or underground AMPS network coverage. The RF propagation characteristics of an 800 MHz signal in an AMPS network may be able to penetrate such structures better than a 1900 MHz signal in a CDMA network; therefore, a call maintained by the CDMA network could lose quality or be dropped. Finally, because large urban areas are typically converted to CDMA before rural areas, the major highways between such areas will also be converted to CDMA to provide seamless coverage for travelers between such areas. However, as a mobile unit exits the highway, it also exits CDMA coverage area, eventually resulting in a call-in-progress being dropped.

Alternatively, two CDMA networks may be installed next to a each other, wherein the first CDMA network operates at a different frequency from the second CDMA network. In such a case, there may be situations in which it would be advantageous to effect the handoff of a call from a CDMA cell site in the first CDMA network to a CDMA cell site in the second CDMA network. For example, there may be areas that are covered by the second CDMA network that are not covered by the first CDMA network. Also, the second CDMA network may utilize a different frequency than that of the first CDMA network because of other frequency-based services located in the area of the second CDMA network.

In the foregoing cases, it would be beneficial to handoff a call from a CDMA network to a second cellular network once the call has degraded to a point at which it appears that the call will eventually be dropped. Currently, there are various methods for performing the hard handoff of a call from a CDMA network to the second network, including the use of pilot beacon transmitters or round trip delay ("RTD") measurements. When using the pilot beacon transmitter method, the cells of the second network that are adjacent to the CDMA network are each outfitted with a pilot beacon transmitter. When the mobile unit is leaving the CDMA network, a determination is made as to which of the signals from the pilot beacon transmitters is strongest. The pilot beacon transmitter with the strongest signal represents a target cell of the second network that should receive the handoff. When using the RTD measurement method, complex target selection mechanisms chart the location of the mobile unit and determine when and where to handoff.

Such conventional handoff methods typically present numerous difficulties. For one, the pilot signal transmitters are very expensive. In addition, the transmission of additional signals by the pilot beacon transmitters relates to increased interference and performance degradation problems. Furthermore, the conventional RTD measurement